Effect of salinity on germination, growth, yield and yield attributes of wheat

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ABSTRACT: A pot experiment was conducted during 2010-11 in the Department of Agriculture Botany Janta P.G. College Ajeetmal, Auraiya(U.P.), India. Eight genotypes of wheat are selected with varying in their salt tolerance level, to evaluate effect of salinity on germination, growth, and yield related parameters. Lower salinity (3dsm^{-1}) did not affect the germination, growth and yield attributing parameters. Higher salinity levels reduced germination, growth and yield attributing parameters. Genotypes K9644 and K9465 showed maximum reduction in all these regards. Genotypes K9006, K8434, KRL1-4, K88 and HD2733 showed hardness against higher levels of salinity.

Key words: salinity, tolerance, growth, yield, wheat.

INTRODUCTION

High level of salts in the soil can often cause serious limitations to agricultural production and land development. The main factors that contribute to this problem are the arid and semiarid climates and the salt load in the water used for irrigation. The soil salinity may cause several deleterious effects on growth and development of plants at physiological and biochemical level (Munns, 2002). These effects can be due to low osmotic potential of soil solution, specific ion effects, and nutritional imbalances or combined effect of all these factors (Marchner, 1995; Zalba and Peinemann, 1998). Wheat is the second important cereal crop (after rice) in India. Wheat as a crop, more tolerant at germination stage but highly sensitive to salinity at later stage (Francois *et.al.,* 1986).Higher levels of salt concentration in the germinating media to build up the high osmotic pressure of the solution which will prevent intake of water which is necessary for germination. Higher salt cause toxic effect on embryo. Higher salinity delayed and reduced germination percentage (Ramaden, 1986).Salinity decreased germination percent, root length, callus size, coleoptile length and seedling growth (Lallu and Dixit, 2005; Ganndha*et. al.,* 2005; Bera*et. al.,* 2006 and Agnihotri*et. al.,* 2006). Plant height, stem diameter, dry weight decreased with increasing levels of salinity (Azoz*et.al*., 2004; Asha and Dhingra,2007). Salinity reduced fertile ears, ear length, grain yield, straw yield, harvest index and test weight (Francois et.al.,1986;Sigh et.al.1988 and Asha and Dhingra ,2007).The response of plants exposed to salinity stress is a decrease in plant water potential, which reduces plant water use efficiency (Cha-um, *et. al.,* 2004). The salt tolerant species possesses a high capacity to resist salt stress through the biosynthesis and accumulation of compatible solutes. These substances raise the overall osmotic pressure within the cell, thereby enabling plant cell to maintain both turgor and the driving gradient for water uptake (Hasegawa *et. al.,* 2000; Cha-um, *et. al*., 2004). Hence, the present study was aimed to investigate the adverse effect of salinity on germination, growth behavior and yield and yield attributes of different genotypes of wheat.

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MATERIALS AND METHODS:

Eight wheat genotypes (KRL1-4,K8434,K88,K9644,K9465,K9006,HD 2733 and HD 2329) differing in their tolerance to salinity were evaluated at different levels of salt stress *i.e.* EC 3, 6, 9 and 12 dsm^{-1} in addition to control. Soils samples were collected from Experimental Research Farm Department of Agriculture Botany Janta P.G. College Ajeetmal, Auraiya(U.P.),India. The samples are air-dried, pulverized and sieved in laboratory to make homogenous mixture. 120 clay pots of 12 inch size were selected and thoroughly washed. The inner portion of pot was lined with polythene sheet to check loss of water as well as other elements. Pots are divided in to 24 groups for five treatments including control. The pots were arranged to completely randomized design with three replication of each treatment. A basal dose of N at 100 mg/kg soil as urea, P_2O_5 at 90 mg/kg as single super phosphate and K at 120 mg/ kg as potassium sulphate were mixed in to soil prior to seed sowing. The remaining N was applied after first irrigation. In each pot 15 seeds were shown and thinned to five uniform plants/pot after seedling emergence at crown root stage.

GROWTH MEASUREMENT:

Germination count was made after the radicle emergence (10 DAS) and finally it was presented in percent for each variety after 15 DAS. Plant height was measured in centimeters from the base of stem to the top most leaf with the help of meter scale. The total number of tillers was counted which emerged out from the tagged mother plant. The oven dried samples were weighed separately and dry matter content of whole plant was weighed in electrical balance to the milligram. Ear number was counted at harvest. The length of main ear was measured from the base of the ear up to its tip. Grain numbers produced by per tiller of each tagged plant were separately counted. Grain and straw yield of each plant was weighed and recorded. All the plants from each pot were harvested, and left for sun drying. After threshing samples, grain yield per plant was recorded on average basis. To observe effect on grain filling 100 seeds from each replication were weighed separately and multiplied by 10 to obtain the test weight of seeds. The sum of the grain and straw yield per plant recorded. Harvest index were calculated by the formula suggested by Donald (1962) as follow:

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

RESULT AND DISCUSSION:

Application of salt to wheat genotypes at 3 dsm^{-1} had no adverse effect rather it proved better among all the levels of salinity. Germination percent (Table 1) of wheat genotypes was not affected by salinity at EC 3 dsm^{-1}. Further, increased salinity levels reduced germination percent by 40 % (at 10 DAS) and 28 % (at 15 DAS).Varieties K9006, K8434, KRL1-4, K88 and HD 2233 exhibited better tolerance against higher levels of salinity. Delayed and reduced germination percent seem to be due to less absorption of water from soil which resulting in increasing osmotic pressure of soil water due to higher amount of salt present in the soil solution. Similar finding were also reported by earlier by Khatkar and Kuhad (2000) in wheat, Shirazi (2001), Lallu and Dixit (2005) in mustard and Bera*et. al., (*2006) in chickpea. In case of tolerant genotypes accumulation of osmotically active substances such as sugar, organic acid, proline, glycine, K^+, and Cl^- which provide nutrient acquition, ion selectivity and osmotic adjustment to salinity. Plant height (Table 1) increased by salinity up to the level of 3 dsm^{-1}, beyond that a significant reduction was noted by 33% at 25 DAS, 23% at 75 DAS and 22% at 90 DAS. Among varieties lesser reduction was noted in K9006, K8434, KRL1-4 and K88 over other varieties. Minimum plant height was recorded in variety K9644. The tiller production per plant (Table 1) was minimum at 25 DAS thereafter, it increased up to 75 DAS and it was reduced later. Level of salinity from 6dsm^{-1} up to 12dsm^{-1} showed a significant reduction by 28%, 22% and 23% at various stages of plant growth. Variety K 8434 showed maximum tiller production followed by K9006, KRL1-4, K88 and HD 2733, while the lowest tiller number was observed in K9644. Dry weight (Table 1) was minimum at 25DAS and maximum at 90 DAS. The total dry weight increased about seven times from 25 to 75 DAS and two times from 75 to 90 DAS. Increase in the level of salinity > 3 dsm^{-1} showed a drastic reduction at 25DAS (28%), at 75 DAS (29%) and at 90 DAS (28%).Variety K9006 accumulated maximum dry weight, while variety K9644 showed poor performance. Adverse effect of salinity on the above parameters might be due to fewer uptakes of water and nutrients from the growing media due to higher concentration of salts present in the root zone, which may causes imbalances in osmotic pressure. Reduced growth under salt stress might be due to reduced transport of essential nutrient to the shoot (Tarmatt and Munns, 1986; Dager*et.al.,* 2004). Cherian and Reddy (2000) reported that ECe level 7.5 dsm^{-1} quit detrimental causing about 60 percent decline in dry matter in *Suaedanudiflora.* Reduction in dry matter accumulation in plant seems to be increasing levels of salinity (Sharma, 2003).Under condition of salinity tolerance vigorous growth and continual replacement of lost leaves results in dilution of salt concentration in plant system (Yeo and Flower, 1984).Tolerant genotypes can be minimized salt uptake, potential salt load per unit of new growth and provide better water use efficiency (Flower *et al*., 1988) Salinity level >3dsm-1 showed a reduction about 26 % in ear length (Table 2). Variety K9006 had maximum ear length. Grain yield and straw yield per plant significantly reduced by 40 % and 34 % due to salinity > 3 dsm-1. Genotypes K9006, K8434, KRL1-4, K88 and HD 2733 showed better tolerance against higher levels of salinity. Biological yield, harvest index and test weight were significantly reduced by salinity. Genotype K9006 produced maximum value and genotype K9644 showed minimum value (Table 2) Salinity may directly or indirectly inhibit cell division, cell enlargement, which results in reduction of shoot length, number of leaves, dry matter accumulation, leaf size, mobilization of food material from source to sink and increased root shoot ratio (Francois *et al*., 1986; Mass and Poss, 1989; Rawson, 1988) found similar results. Singh and Singh (1991) reported that yield and yield attributes decreased markedly with increasing levels of sodicity. Salt stress of Ec6dsm-1 and 10 dsm-1 decreased grain, straw yield and harvest index (Afria and Nornolia, 1999; Asha and Dhingra, 2007). Tolerant genotypes had a capability to better nutrient and water absorption which provide maximum leaf area that resulting in better accumulation of photo-assimilate in plant.

CONCLUSION:

The assessment of the effect of salinity on the germination, growth and yield attributes in wheat genotypes lead to conclude that all the considered parameters were significantly affected by salt stress .The results of this study are in accordance with earlier reports which show that proline act as protective compound and higher potassium sodium ratio provide safety during salt stress. These organic solutes and ionic balances could be used as physiological markers for assessing salt tolerance in wheat.

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Genotypes/ Salinity levels (EC dsm^{-1})	Germination (%) DAS		Plant height (cm) DAS			Number of tillers DAS			Dry weight (g) DAS		
	10	15	25	75	90	25	75	90	25	75	90
KRL 1-4											
control	62.90	89.20	6.8	66.10	67.10	3.0	4.3	3.7	0.178	3.27	9.80
3	63.40	90.10	7.0	68.00	68.60	3.3	4.5	4.0	0.188	3.40	10.97
6	51.80	75.30	6.5	62.10	64.20	2.8	4.2	3.5	0.138	2.70	8.48
9	38.40	62.50	5.8	45.50	60.10	2.3	3.9	3.3	0.127	2.35	6.40
12	28.50	61.40	4.3	42.40	56.20	2.1	3.2	2.9	0.080	1.58	4.40
Mean	49.00	75.10	6.08	56.82	63.24	2.70	4.02	3.48	0.142	2.66	8.01
K8434											
Control	63.20	88.50	6.8	64.70	72.20	3.0	4.2	3.7	0.180	3.24	10.30
3	63.80	89.30	7.2	65.50	74.10	3.3	4.5	3.9	0.195	3.75	11.20
6	52.00	80.40	6.5	56.50	64.40	2.8	4.3	3.0	0.140	2.85	9.10
9	39.00	72.70	5.7	52.10	64.00	2.4	3.7	3.2	0.125	2.35	7.30
12	27.40	61.30	4.8	48.00	49.00	2.0	2.9	2.8	0.070	1.70	4.20
Mean	49.08	78.44	6.2	57.36	64.14	2.66	3.92	3.32	0.142	2.77	8.42
K88											
Control	62.10	91.10	7.0	65.10	71.10	2.9	4.2	3.6	0.168	3.15	10.20
3	63.50	92.20	7.2	67.10	73.20	3.1	4.4	3.8	0.170	3.35	11.35
6	51.50	73.40	6.2	60.50	62.40	2.7	4.1	3.1	0.137	2.65	8.40
9	38.50	61.50	5.6	45.20	58.00	2.2	3.8	3.1	0.119	2.30	6.30
12	27.30	49.00	4.0	41.80	50.00	2.0	3.0	2.7	0.097	1.65	3.60
Mean	48.58	73.44	6.0	44.50	62.94	2.66	3.90	3.26	0.139	2.62	7.97
K9644											
Control	61.40	90.00	6.0	56.25	63.40	2.5	4.3	3.6	0.170	3.32	10.00
3	62.20	91.50	6.4	57.30	64.80	2.7	4.5	3.8	0.173	3.35	11.10
6	51.20	70.50	5.5	51.40	57.80	2.1	3.2	2.8	0.125	2.40	7.30
9	37.70	60.10	4.6	43.70	49.50	1.7	2.5	2.3	0.105	1.87	5.40
12	29.90	48.10	3.1	40.50	45.30	1.5	2.1	1.9	0.078	1.31	3.90
Mean	47.88	72.04	5.10	49.83	56.16	2.0	3.32	2.88	0.130	2.45	7.54
K9465											
Control	62.40	91.50	7.1	56.25	60.30	2.6	4.2	3.7	0.171	3.18	10.12
3	63.20	92.30	7.3	57.30	61.50	2.8	4.3	3.9	0.173	3.45	11.10
6	50.50	70.40	6.1	51.40	57.40	1.9	3.5	2.9	0.120	2.50	7.60
9	38.40	60.10	4.7	43.70	53.50	1.7	2.9	2.3	0.109	1.85	5.50
12	27.00	48.10	3.2	40.50	48.70	1.2	2.2	1.7	0.088	1.35	3.60
Mean	48.22	72.04	5.68	49.83	56.28	2.04	3.42	2.9	0.132	2.46	7.58
K9006											
Control	60.60	90.50	7.0	60.20	73.20	3.1	4.4	3.8	0.174	3.25	10.32
3	61.20	91.40	7.3	61.40	75.10	3.3	4.6	3.9	0.184	3.80	12.10
6	59.30	81.60	6.7	58.10	65.50	2.9	4.2	3.7	0.148	2.90	9.20
9	50.60	74.10	5.5	56.10	60.50	2.1	3.8	3.2	0.129	2.45	6.00
12	40.50	62.20	5.2	51.10	48.10	2.0	3.1	2.7	0.090	1.80	5.15
Mean	53.96	79.96	6.34	57.38	64.48	2.68	4.02	3.46	0.145	2.84	8.55
HD2733											
Control	61.50	91.80	5.9	61.50	72.10	3.0	4.0	3.5	0.155	3.35	10.60
3	62.40	92.60	6.1	62.70	73.70	3.2	4.2	3.7	0.180	3.42	11.60
6	51.20	71.70	5.8	58.00	66.60	2.6	3.9	3.1	0.135	2.60	6.85
9	38.60	60.90	5.6	44.20	51.20	2.2	3.7	3.0	0120	2.20	5.35
12	27.50	48.50	5.0	41.40	46.70	1.9	3.1	2.6	0.095	1.48	3.70
Mean	48.30	73.10	5.84	53.56	62.06	2.58	3.78	3.18	0.137	2.84	7.62
HD 2329											
Control	62.00	91.70	6.9	56.25	68.30	2.7	4.6	3.9	0.168	3.30	10.32
3	63.20	92.40	7.1	57.30	69.50	2.9	4.7	4.3	0.175	3.35	11.29
6	50.50	71.60	6.5	51.40	63.10	2.0	3.7	3.1	0.140	2.60	7.28
9	38.40	60.00	4.9	43.70	50.40	1.8	2.8	2.5	0.105	1.91	5.40
12	27.00	48.21	3.3	40.50	46.30	1.6	2.2	2.1	0.085	1.28	3.60
Mean	48.22	72.78	5.74	49.83	59.50	2.22	3.6	3.8	0.134	2.48	7.57
S	1.05	1.97	0.16	1.15	1.07	0.12	0.16	1.80	0.0042	0.123	0.31
G	1.33	2.50	0.21	1.45	1.36	0.16	0.21	0.22	0.0053	0.155	0.40
CD at 5%(S x G)	2.97	5.60	0.47	3.26	3.04	0.35	0.48	0.51	0.0119	0.348	0.89

Table: 1. Effect of salinity on germination, plant height, tiller numbers and dry weight in different genotypes of wheat.

Genotypes/ Salinity level (dsm-^{1})	Ear Number	Ear length	Grain Number/plant	Grain yield/plant	Straw yield/Plant	Biological yield/Plant	Harvest index	Test weight
KRL1-4								
control	3.70	11.20	172.80	6.86	9.80	16.66	1.24	41.20
	3.80	11.80	194.40	7.80	11.20	19.00	41.35	42.80
6	3.35	8.08	164.00	6.42	10.80	17.22	38.58	39.80
9	2.95	7.60	141.00	5.38	9.40	12.78	36.80	39.70
12	1.95	6.80	110.00	4.20	7.80	12.00	34.70	37.90
Mean	3.15	9.24	156.44	6.13	9.80	15.93	38.54	40.28
K8434								
Control	3.43	11.48	169.00	7.48	11.20	18.68	39.30	41.48
3	3.60	11.48	188.20	8.22	12.38	20.60	40.00	41.55
6	3.35	9.40	170.00	6.75	10.48	17.23	39.10	41.15
9	3.20	7.85	146.00	5.22	8.40	13.62	38.15	40.68
12	2.70	6.60	120.02	4.30	7.08	11.38	38.09	39.35
Mean	3.25	9.36	158.64	6.34	9.90	16.30	38.92	40.84
K88								
Control	3.67	11.35	170.85	6.68	10.30	16.98	39.40	41.18
3	3.79	11.80	193.60	7.60	11.90	19.50	39.80	41.20
6	3.40	8.08	162.80	6.40	10.80	17.20	38.30	39.90
9	2.95	7.60	140.60	5.48	8.30	13.78	37.60	39.80
12	1.90	6.80	112.70	4.35	7.20	11.55	36.30	39.20
Mean	3.14	9.21	156.12	6.10	9.70	15.80	38.28	40.25
K9644								
Control	3.60	10.12	168.35	7.10	9.50	16.60	39.78	38.70
3	3.65	10.35	117.85	7.45	11.05	18.50	39.80	38.62
6	2.90	8.70	129.80	5.44	7.95	13.39	37.34	38.40
9	1.95	7.60	76.80	3.18	5.77	8.95	34.60	37.80
12	1.80	6.00	58.80	2.40	4.88	7.28	33.58	36.90
Mean	2.78	8.55	122.32	5.11	7.83	12.94	37.02	38.08
K9465								
Control	3.55	9.45	175.60	6.97	10.32	17.29	40.38	39.38
3	3.60	10.10	185.70	7.38	10.95	18.33	40.52	39.45
6	2.80	9.05	130.80	5.24	8.45	13.69	37.52	39.37
9	2.20	8.40	89.60	3.37	6.16	9.53	35.20	39.25
12	1.80	7.05	67.70	2.65	4.85	7.50	32.44	38.90
Mean	2.79	8.81	129.88	5.12	8.14	13.26	37.21	39.27
K9006								
Control	3.65	13.09	188.85	7.20	11.32	18.52	39.87	42.35
3	3.78	13.40	206.50	8.10	12.35	20.45	39.90	42.40
6	3.35	12.78	176.50	6.20	10.55	16.75	39.22	41.95
9	2.90	12.40	133.80	5.98	8.30	14.28	38.44	41.40
12	2.60	10.15	110.50	4.70	7.09	11.79	38.00	40.70
Mean	3.25	12.36	163.23	6.43	9.92	16.35	39.08	41.76
H D 2733								
Control	3.50	10.20	185.90	7.00	10.50	17.50	38.90	40.20
3	3.65	11.10	202.60	7.80	12.05	19.85	38.94	40.12
6	3.40	9.90	180.60	6.30	10.40	16.70	38.00	39.95
9	2.10	7.80	140.00	5.30	9.25	14.55	37.32	39.55
12	1.85	6.80	80.60	3.15	7.40	10.55	36.64	39.30
Mean	2.90	9.16	137.94	5.91	8.52	14.43	37.96	39.82
HD2329								
Control	3.68	10.15	182.65	7.20	10.60	17.80	40.80	40.38
3	3.75	11.30	190.85	7.70	11.10	18.80	40.92	40.40
6	2.85	9.15	137.60	5.34	8.73	14.07	37.60	39.40
9	2.25	8.60	91.90	3.58	6.38	9.96	35.30	39.38
12	1.80	6.25	73.80	2.65	5.27	7.92	32.30	38.80
Mean	2.86	9.09	135.36	5.29	8.41	13.70	37.38	39.67
S	0.131	0.327	4.54	0.281	0.321	0.5370	0.963	0.981
G	0.165	0.413	5.75	0.355	0.406	0.679	1.219	1.241
CD at 5%(S x G)	0.370	0.925	12.86	0.795	0.908	1.519	2.726	2.776

Table.2: Effect of salinity on ear number, ear length, grain number, grain yield, straw yield, biological yield, harvest index and test weight of different genotypes of wheat.